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Monterey, California

THESIS

INVESTIGATION AND APPLICATION OF RECENT WEB-BASED TECHNOLOGIES TO THE TEACHING OF ELECTRICAL ENGINEERING COURSES

by

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This thesis is part of an effort by the Department of Electrical and Computer (ECE) Engineering to implement distributed learning to better serve its students. Distributed learning is especially useful for a modern technologically-oriented military, which is geographically distributed. The goal of this thesis is to develop a prototype web-based course, specifically, EC2820 - Digital Logic Design. A primary sub-goal is to quantify time required and to understand the tradeoffs involved. A secondary sub-goal is to evaluate web page tools.

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INVESTIGATION AND APPLICATION OF RECENT WEB-BASED TECHNOLOGIES TO THE TEACHING OF ELECTRICAL ENGINEERING COURSES

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B.S., Nanyang Technological University, 1994

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ABSTRACT

This thesis is part of an effort by the Department of Electrical and Computer (ECE) Engineering to implement distributed learning to better serve its students. Distributed learning is especially useful for a modern technologically-oriented military, which is geographically distributed. The goal of this thesis is to develop a prototype web-based course, specifically, EC2820 - Digital Logic Design. A primary sub-goal is to quantify time required and to understand the tradeoffs involved. A secondary sub-goal is to evaluate web page tools.

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I. INTRODUCTION

A. AREA OF RESEARCH

The World Wide Web is causing a major change education. There has been a rapid increase in the number of people using the Web, and this has created significant potential for university teaching. There is now the prospect of "distributed learning" with students at perhaps many different remote sites. It has created a new paradigm for teaching and learning different from the traditional classroom experience.

The Department of Electrical and Computer Engineering (ECE) at the Naval Postgraduate School (NPS) has initiated a Distributed Learning program intended to achieve two goals:

- extend the benefits of a militarily-relevant electrical and computer engineering education to more people.

- enhance existing on-site courses by introducing multimedia into the learning process.

The ECE department oversees the Navy's graduate program of education in signals, circuits, networking, communications, power systems and computing. Rapid changes in technology have made education for electrical and computer engineers even more important than in the past. At the same time, job demands have made it difficult for people

to devote the time needed to improve their effectiveness. Distributed learning is seen as a cost/time-effective solution to this problem.

The first goal of extending education to more people includes both new students in the form of short courses, as well as a full Master of Science or Doctor of Philosophy program, and former students in the form of continuing education. The second goal relates to improving the way students learn. The multimedia capabilities of the Web allow the use of color, graphics, animation and interaction, in ways that have not been possible in the past.

The goal of this thesis is to develop a prototype web-based course, specifically, EC2820 - Digital Logic Design, which shall include self-paced lectures, quizzes, laboratory write-ups, grading criteria, special notes, and so forth. A primary sub-goal is to quantify time required to develop a web-based course and to understand the tradeoffs involved. A secondary sub-goal is to evaluate web development tools.

B. RESEARCH QUESTIONS

- Which recent Web technology is the most suitable (e.g. cost/time-effective)for the production of Web-Based Training (WBT) ECE courses?
- What is the recommended approach, design and development process that should be adopted for future productions?

- What training is required of individuals who do such production?

C. RESULTS OF THE RESEARCH

This research has established a step-by-step design and development process for WBT course production, which have been adopted to successfully complete the EC2820 - Digital Logic Design On-Line Course, and the EC2820 Homepage from which the on-line course is launched. This research has also determined the Web technology suitable for future WBT course production efforts by the ECE department.

Chapter II discusses the benefits of Distributed Learning. It also covers the approach and the resources required to undertake a WBT course production. In addition, it addresses the principal considerations that need to be examined when selecting a course for WBT.

Chapter III, Recent Technologies For WBT Course Production, presents the research findings on several Web technologies, currently used to produce WBT courses. The pros and cons of each type were examined and compared.

Chapter IV explains the step-by-step design and development process of producing the EC2820 Homepage and the EC2820 - Digital Logic Design On-Line Course. It also covers the use of a popular software development approach known as

"incremental development" that was specifically used to design and develop the on-line course.

Chapter V contains the conclusions and recommendations.

II. DISTRIBUTED LEARNING

A. WHAT IS DISTRIBUTED LEARNING?

Distributed learning allows students from anywhere in the world to study at home or work. The means of delivery of the educational materials include satellite broadcast, broadband broadcast, home video, two-way compressed video, audio conferencing, text-based correspondence courses, television broadcast, and the Web.

New and exciting distributed learning methodology with extensive use of multimedia, using the Web to provide Web-based Training (WBT) courses, is rapidly being developed, making the Web currently the most cost/time-effective option. Also, the Web is easily accessible by users using computers connected to the internet from a location of their choice, and more importantly at their own pace and in their own time. Appendix A discusses important principles in the use of multimedia for distributed learning.

B. WHY DISTRIBUTED LEARNING?

Many organizations have gone into distributed learning for the following reasons:

- To extend education to more people.
- To augment present traditional education.

- To provide education, tailored to specific needs.
- To improve costs and efficiencies by distributing instructional components inexpensively to physically remote locations.

C. RESOURCES & TIME REQUIRED FOR WBT COURSE PRODUCTION

In order to produce an effective WBT course, a design and development team consisting of the following members has to be formed:

1. Content Expert

The content expert is usually the instructor or the producer of the course materials used for the traditional teaching method. He/she is usually the team leader and is the one to decide what materials to include in the WBT course.

2. Web Designer

The Web designer is responsible to transform the course materials from their raw form (hand-written or type-written) into a digital form suitable for interactive presentations using multimedia software tools. He/she will determine how interactivity can be used to encourage active involvement from the users, and how animations can be used to illustrate difficult concepts and complex processes.

3. Education Specialist

The education specialist is responsible for the organization and presentation of the WBT course materials to ensure that they become the effective learning tools.

4. Graphic Designer / Artist

The graphic designer is responsible to transform figures, tables, and photos in their raw form (hand-drawn, computer-drawn or any analog type) into computer graphics suitably compressed to reduce their size to allow fast downloading time of the WBT course into the user's computers. He/she will also be responsible for implementing any animations required.

5. Programmer

In WBT course production, where there is programming involved, a programmer is required. He/she is responsible to code, test, interface and integrate all the WBT components.

6. Server Administrator

The server administrator is responsible for providing a website for publishing the WBT course, and protecting its contents from unauthorized access and modification.

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III. RECENT TECHNOLOGIES FOR WBT COURSE PRODUCTION

In evaluating a suitable technology for WBT course production, the following characteristics were preferred:

- Uses Commercial-Off-the-Shelf (COTS) software.
- Has short development time
- Encourages interactivity.
- Has good maintenance/upgrade support
- Is cost effective.

Several recent technologies used to develop WBT courses were studied. They include the following:

- Lecture materials published on web pages.
- Slide shows, similar to those produced by Microsoft Powerpoint, that run on the web browser.
- An interactive course developed using a high level language such as Java or Visual Basic.
- An interactive course developed using a proprietary software package.
- An interactive course developed using commercial-off-the-shelf (COTS) authoring tools such as the Macromedia Director 7, Macromedia Authorware 5 and Asymetrix Toolbook.

A. LECTURE MATERIALS PUBLISHED ON WEB PAGES

Publishing lecture materials directly on web pages is the simplest, the easiest and the fastest to produce WBT

courses. Essentially, the lecture materials are digitized with text type-written, tables created using a word-processing application, and figures scanned or drawn with a graphics-editing program.

A sample is shown Figure 1 below.

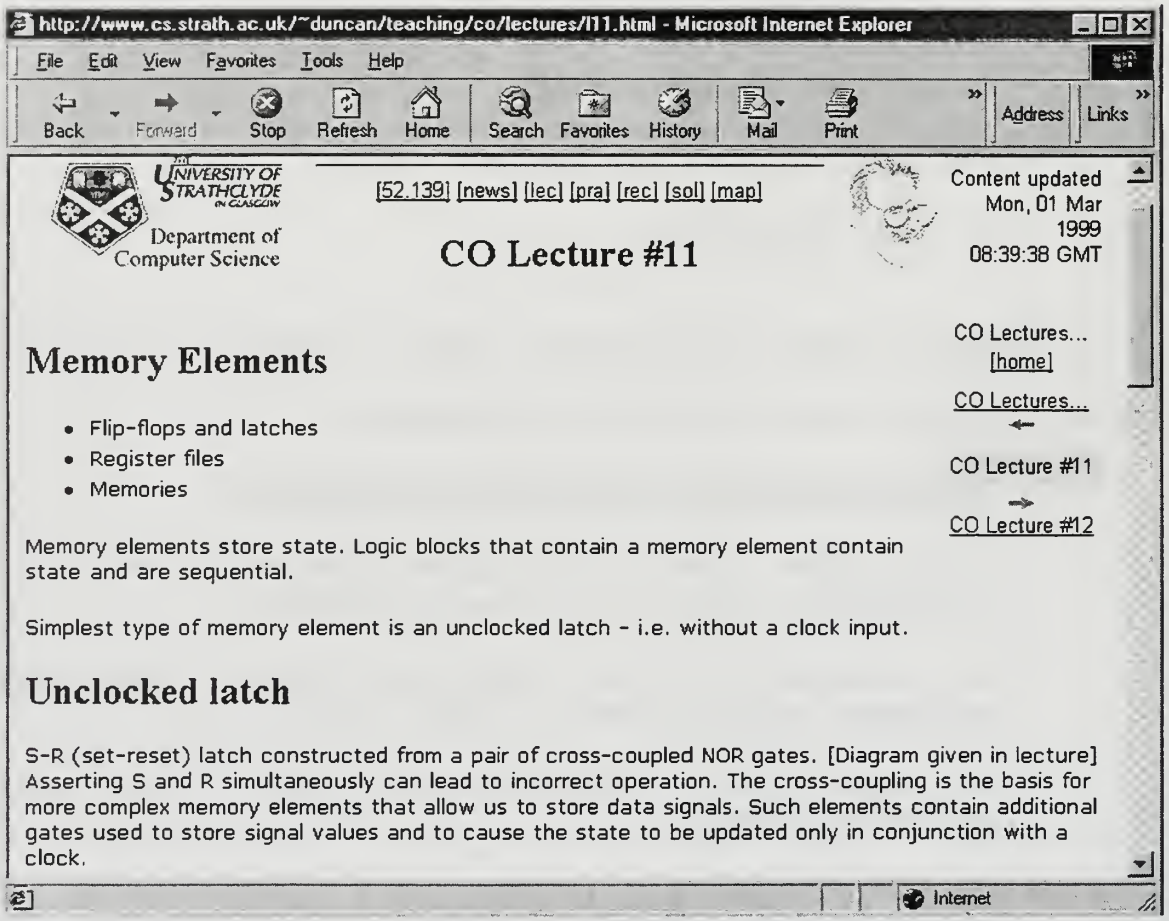

Figure 1. Example Of Lecture Materials Published On A Web Page

The main disadvantage of this form of WBT course is that it lacks the two elements, animation and interactivity, that are vital for effective learning. It does not have the animation feature that is useful for illustration of

difficult concepts or complex processes. Without interactivity, we cannot get the users to actively participate in the course, and also to give feedback.

B. SLIDE SHOWS

Slide shows are simple and easy to produce. The same Microsoft Powerpoint slides that an instructor uses for his/her traditional classroom lectures can be easily imported into a website for use as a WBT course. Minimal development effort is required in this case.

A sample of a WBT course that is of the slide show form is shown in Figure 2 below. Similar to the lecture materials published on Web pages described earlier, the slide shows lack animation and interactivity.

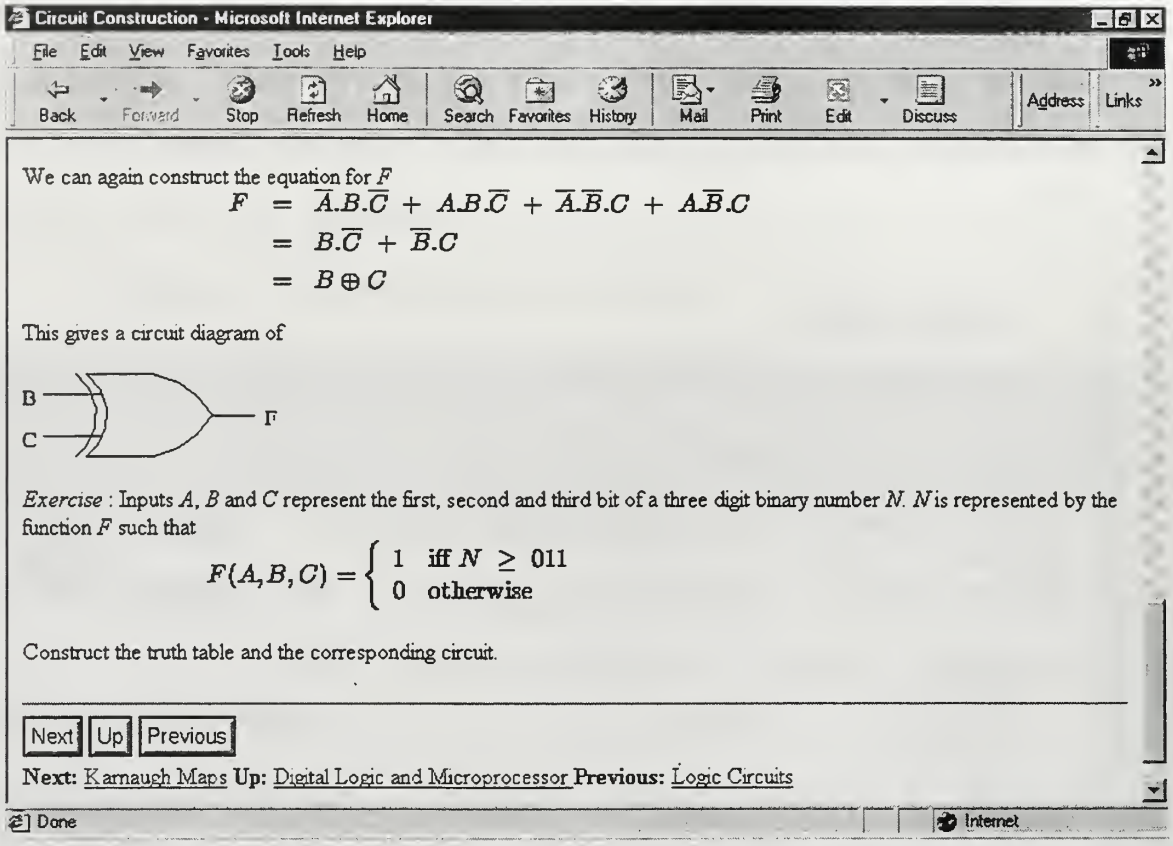

Figure 2. Slide Show

C. WBT COURSE DEVELOPED USING A HIGH LEVEL LANGUAGE

In the past, high level languages such as Java, Visual Basic, C++, etc. were used by many to develop Computer-based Training (CBT) courses. Today, a small number of developers are still using these high level languages to produce WBT courses.

The main advantage of using high level languages is that they are highly flexible and they allow full customization to meet practically all the requirements of an effective WBT course.

However, the main disadvantage is its high development cost in terms of time and money. Many subroutines, functions, libraries, etc. must be created from scratch to support specific requirements, such as user interface, screen navigations, search feature, animation and interactivity.

The other disadvantage is its poor maintainability. The program codes are inherently long, and, more often than not, developers fail to document them adequately. Hence, modifications and upgrades become both time-consuming and tedious.

Nowadays, application-specific software tools have been made available to help developers produce WBT courses. They are simple to learn and easy to use. They are discussed in the next two sections.

D. WBT COURSE DEVELOPED USING A PROPRIETARY SOFTWARE PACKAGE

Proprietary software tools tailored for WBT course production are becoming increasingly popular with organizations transiting into distributed learning. The main attraction to these tools is the short learning curve.

However, many of these tools are created by small software companies that lack the experience and comprehensive customer support of the more established

companies. As compared to COTS authoring tools to be discussed in the next section, these proprietary tools are usually more expensive (US$5,000 to US$30,000). Often, they do not have as many features and flexibility.

A sample WBT course developed using a proprietary software tool is shown Figure 3 below.

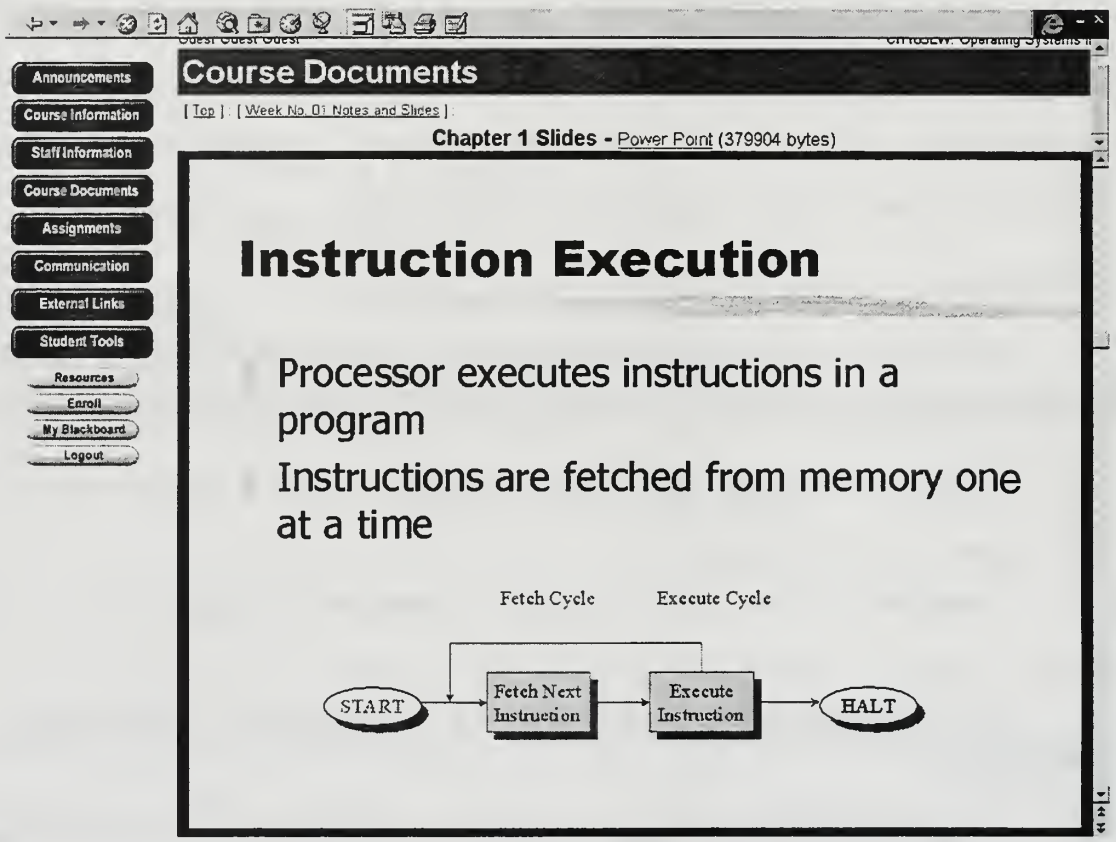

Figure 3. WBT Course Developed Using A Proprietary Software Tools (http://blackboard.com/courses/CIT185LW/)

E. WBT COURSE DEVELOPED USING COMMERCIAL-OFF-THE-SHELF (COTS) INTERACTIVE SOFTWARE TOOLS

There are several COTS interactive software tools for WBT course development available in the market today. Some

have been used since the development of CBT courses started, and have since improved, upgraded and packed with more advanced features to produce powerful CBT and WBT courses.

The main advantages of using these COTS tools include shorter learning curve, ease of use, excellent maintainability and upgradeability.

F. RECOMMENDED TECHNOLOGY FOR USE

Summarized in Table 1 below are all the technologies discussed above that are available for WBT course production compared against the preferred characteristics mentioned earlier in the chapter.

	COTS software?	Development time?	Interactive?	Good maint/ upgrade support?	Cost effective?
Lecture materials published as web pages	Yes	Short	No	Yes	Yes
Slide shows	Yes	Short	No	Yes	Yes
High level language	Yes	Long	Yes	Not so good	Yes
Proprietary software package	No	Short	Yes	Not so good	No
COTS authoring tools	Yes	Moderate	Yes	Yes	Yes

Table 1. Comparison Of Technologies Available

From Table 1, it can be seen that using COTS authoring tools was the most appropriate option for developing the EC2820 - Digital Logic Design On-Line Course.

G. SELECTION OF SOFTWARE TOOLS FOR THE EC2820 ON-LINE COURSE

In selecting the appropriate COTS software tools to use, previous research work done under the thesis project "Interactive Multimedia for Classroom and Web Use" by Darren Harvey were taken into considerations. [Ref.15]

The main software tool selected by the author for creating the interactive on-line course was the Macromedia Authorware 5, with the support of a few other software tools to perform the other functions of a WBT course development as well as the website creation discussed below. These other

tools included graphic editors, text editor, website creation and management tools.

1. Interactive WBT Course Development Tool

Through further research and experimentation, the selection for the main software tool for creating the interactive EC2820 On-Line course was narrowed to the three software tools namely Authorware 5, Director 7, and Flash 3, all of which were from Macromedia.

A summary of the comparison of the three tools is given in Table 2 below. [Ref.12]

	Authorware 5 (US$2400)	Director 7 (US$1000)	Flash 3 (US$350)
Overview	Authorware is the industry-leading tool for creating interactive, rich-media learning applications for delivery over the Web, LANs, CD-ROMs and DVD-ROMs.	Director is the standard for creating and delivering powerful multimedia for the Web, CD-ROMs and DVD-ROMs.	Flash is the standard for creating vector-based animations and graphics that are extremely beautiful, compact and resizable for the Web, CD-ROMs and DVD-ROMs.
Main use	• Computer-based training • Web-based training	• Web-based multimedia • Demos, presentations	• High impact branded sites • Web site interfaces • Narrative animations
Primary Users	• Training developers • Instructional designers • Subject matter experts	• Web developers • Multimedia professionals • Corporate presentation specialists	• Web designers • Animators
User Interface	Icons on a flowline.	Frame-based using a score, powerful scripting language.	Timeline-based, graphical editing tools.

Table 2. Comparison Of Tools Available For WBT Course Development Tool

There were also other similar tools available from other software companies such as Toolbook from Asymetrix

which was the equivalent of Authorware 5, and Premiere from Adobe which was the equivalent of Director 7 and Flash 3.

As shown in Table 2 above, Authorware 5 was optimized for interactive WBT course development and hence it was selected as the main software tool for developing the EC2820 On-Line course. Although Darren Harvey used both Authorware 5 (for main instructional content) and Director 7 (for animation and interaction) in his WBT course development, the author experimented extensively with Authorware 5 and realized that Authorware could perform the animation and interaction functions of Director 7. In fact, the interaction features of Authorware were superior than that of Director. [Ref.15]

Authorware was the leading visual rich-media authoring tool for creating Web and on-line learning applications. The 1999 Computer-Based Training Report by SB Communications, publisher of CBT Solutions Magazine report, ranked Authorware as the Number One in the market every year since 1995.

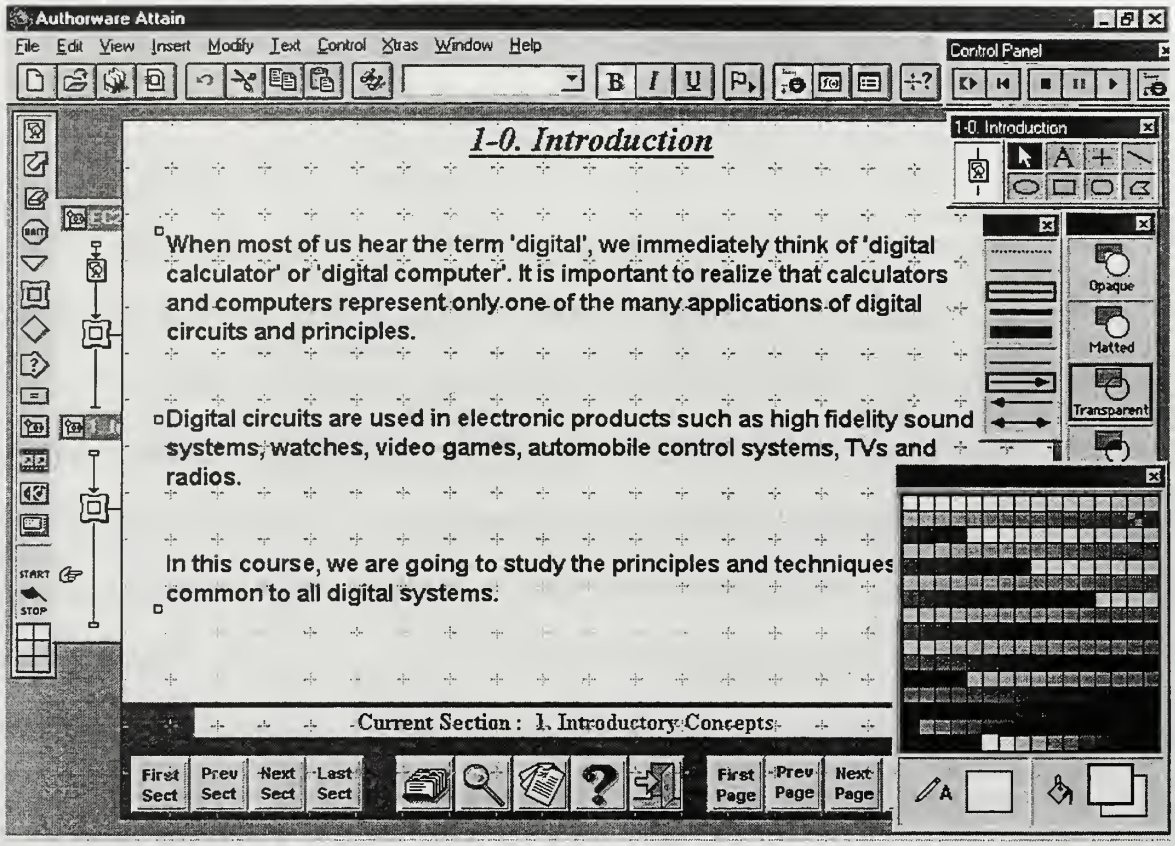

Figure 4. Authorware Developer's Interface

The other key advantages of Authorware are discussed below:

- **Short Learning Curve.** Developers of any skill level can quickly develop media-rich interactive learning applications with the Authorware flowline, icons, and templates. It took the author only three weeks to master the basic features of Authorware. A sample flowline is shown in Figure 5 below.

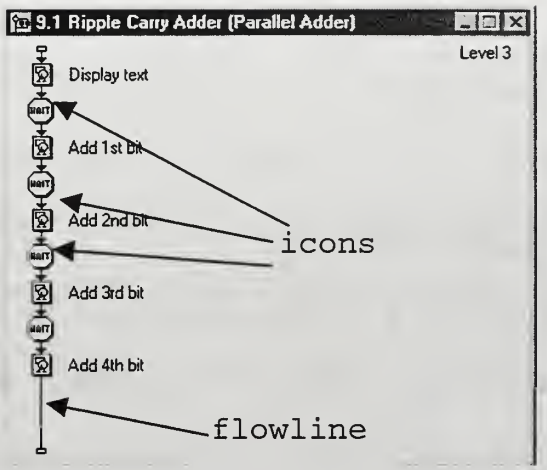

Figure 5. Authorware's Easy To Use Flowline & Icons

- **Highly Interactive.** Authorware maximizes learning with highly-interactive features including hyperlinking, hypertext, full text search and retrieval, and eleven different built-in interactions. It makes it easy to handle a wide variety of media and precisely track and respond to users' actions.

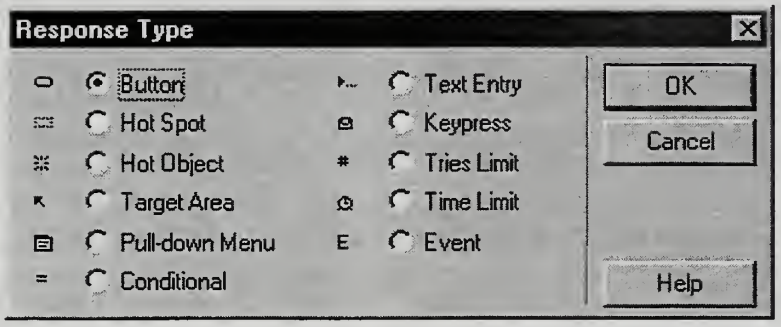

Figure 6. Authorware's Eleven Built-In Interactions

- **Ease of Maintenance and Upgrade.** Authorware represents program flow in graphical form, and it requires little programming for added flexibility. Hence, its program is simple to read and analyze, making it easy to maintain and upgrade.

- **Distribution Flexibility.** With Authorware, one can create learning applications, and deliver them to users on the Web, LANs, or in an executable format on CD-ROMs or DVD-ROMs.

- **Fast Web Download.** Authorware uses advanced compression and streaming techniques for fast downloading of its applications on the Web.

2. Graphics Editors

As authorware's built-in graphics editing function had limited capability, external graphics editors were used to performing the intricate functions of scaling, rotation, flipping, zooming, cropping, cutting, pasting and other manipulations of graphics. There were many good graphics editors in the market such as Coreldraw, Photoshop, Freehand.

Due to unavailability of any of these graphics editors, and also the lack of time to master them, the Microsoft Powerpoint was used to create all the graphics required for the on-line course, and then they imported into Paint Shop Pro, a shareware graphics editor from *http://www.jasc.com*, to compress them into GIF format before inserting them into Authorware. In fact, any available graphics editor would be able to perform the GIF compression function.

Microsoft Powerpoint was used due to its simplicity and user-friendliness. The other reason was the availability of the "multiple undo" feature provided by Powerpoint that was not found in many graphics editors. This feature helped tremendously.

3. Text Editor

The majority of the text used in the on-line course was typed using Microsoft Word instead of the Authorware built-in text editor. The reasons were that the built-in text editor lacked the excellent text formatting, styling, coloring, spelling check and auto-correct features of Microsoft Word.

4. Website Creation And Management Tools

The website creation and management tools provided the many functions needed to plan, create, test, maintain and manage the EC2820 Homepage. Besides presenting the EC2820 course information such as the course objectives, outline, textbook, laboratory information etc., the homepage also served as the platform from which the EC2820 On-Line Course was launched on the Web and accessed by users.

The Macromedia Dreamweaver (US$300) and Microsoft FrontPage 2000 (US$70) were the two website creation and management tools evaluated as they were the two most popularly used recently.

Dreamweaver had more advanced features than the Frontpage 2000. However, in terms of ease of use and user-friendliness, FrontPage 2000, with its look and feel designed very much like the rest of the Microsoft Office 2000 packages, was significantly better.

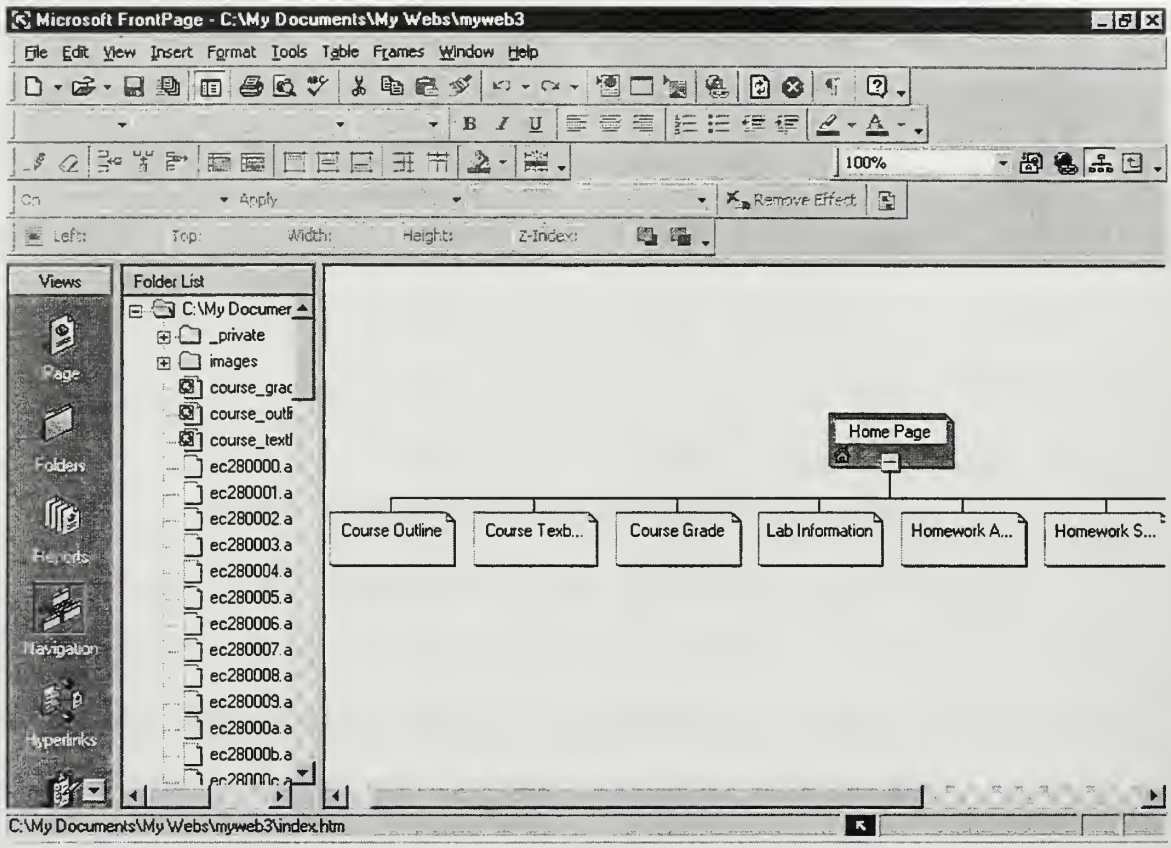

Figure 7. Frontpage 2000

The major weakness of FrontPage 2000 was its lack of compatibility with most web servers. The interactive features offered by FrontPage 2000 such as forms, search, confirmation field etc., could not work on most popular web servers, including the NPS server that was hosting the EC2820 Homepage. In order to make these features work, these servers, hosting web sites created using FrontPage, must install the FrontPage Server Extensions, a proprietary software of Microsoft to support FrontPage interactive components on the web.

Dreamweaver, on the other hand, was compatible with most web servers, and it used cgi scripts to handle the interactive features available, instead of a server extension.

As the EC2820 Homepage did not require any interactive features, and also to cut down on development time, Frontpage 2000 was used to create the EC2820 Homepage. Nevertheless, the homepage could be modified using Dreamweaver to incorporate interactive features subsequently, if needed.

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IV. THE DESIGN AND DEVELOPMENT PROCESS

The process adopted for the design and development of the EC2820 On-Line course was similar to that used for conventional software development, with the exception of a training phase included at the beginning as shown in Figure 8.

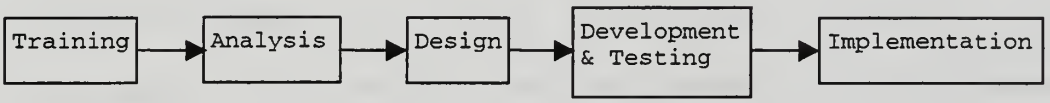

Figure 8. The Design And Development Process

A. TRAINING PHASE

The training phase was required to allow the author to self-acquire the knowledge and skills of various multimedia tools necessary to produce significant web applications for on-line courses. Four Web development and multimedia tools namely Director 7, Authorware 5 Attain, Frontpage 2000 and Dreamweaver 2 were covered over a period of eleven weeks (with normal school lessons ongoing at the same time), as shown in the schedule below. A discussion of the software has been given in Chapter III.

Topic	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11
Learning Director 7	←	—	—	→							
Learning Authorware 5					←	—	→				
Learning FrontPage 2000								←	→		
Learning Dreamweaver 2									←	—	→

Table 3. Training Schedule

B. ANALYSIS

In this phase, the objectives and requirements of creating the EC2820 On-Line Course were understood and translated into an implementation plan. Essentially, two end-products were required; the EC2820 Homepage and the EC2820 On-Line Course. An evaluation of the above mentioned Web development and multimedia software tools were done, and it was decided that the Microsoft FrontPage 2000 and the Macromedia Authorware 5 should be used to develop the homepage and the on-line course, respectively, based on their suitability, ease of use and maintainability as discussed in Chapter III.

With these requirements in mind and having experimented with the software tools, tasks needed to complete the project were determined. The time and effort required of each task were assessed, and time was allocated to each task to ensure that they were achievable in the time available as shown in the Table 4 below.

S/N	TASK	Jul 1999	Aug 1999	Sep 1999	Oct 1999	Nov 1999	Dec 1999	Jan 2000	Feb 2000	Mar 2000
1.	Gathering of Information for EC2820 Homepage	↔								
2.	Design of the EC2820 Homepage	↔								
3.	Obtain Website for the EC2820 Homepage	↔								
4.	Development of the EC2820 Homepage		↔							
5.	Gathering and Understanding of material for the EC2820 On-Line Course	↔								
6.	Design of the EC2820 On-Line Course		↔	↔						
7.	Development of the EC2820 On-Line Course				↔	↔	↔	↔	↔	
8.	Testing		↔	↔	↔	↔	↔	↔	↔	↔
9.	Thesis Report							↔	↔	↔

Table 4. Tasks Schedule

C. DESIGN

1. EC2820 Homepage Design

With the knowledge of FrontPage 2000 and also some guidelines on the "do's and don'ts" of website design [Ref.13 & 14], the layout of the EC2820 Homepage was first designed.

The following design considerations were used:

- **It must be easy to navigate**. Therefore, intuitive navigation menus were prominently displayed at the top and left hand side of each page.
- **Each page must allow access to all of the other Web pages throughout the website.** The same set of navigation menus were placed at the same location on each page for easy access by users.
- **The design throughout the Web site needs to be consistent**. Therefore, the layout of every page was made the same with buttons, background picture, banners, colors standardized.

- **Links to other relevant sites must be provided**. Links to further information on the textbook, the creator of the homepage, the professor-in-charge, NPS, disclaimer, and link to Authorware plug-in were incorporated in the appropriate pages.

- **The pages need to be pleasing to the eye.** Several layouts, fonts style, color combinations and background picture were experimented to give a pleasant look and feel.

The final design used for the EC2820 Homepage can be seen in Figure 9.

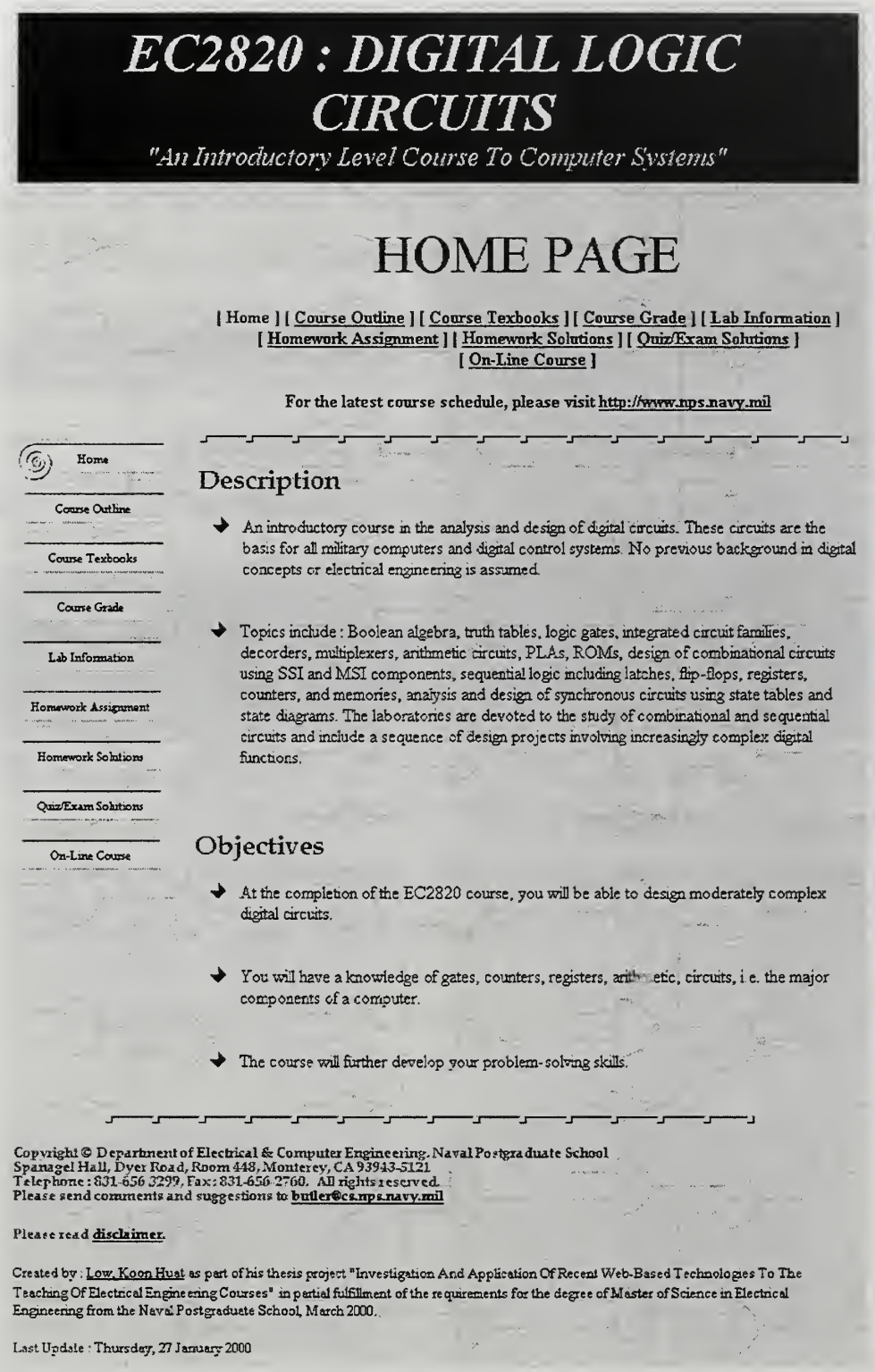

Figure 9. Final Layout Design Used For The EC2820 Homepage

2. EC2820 On-Line Course Design

Unlike the design of the homepage, the design of the EC2820 On-Line Course required more thought and experimentation due to the much larger amount of information that must be handled, more complex navigation, a smaller screen area (640 x 480 resolution to cater to all user screen size), and multiple user accessible functions.

There were about three hundred pages of lecture materials and quizzes to be delivered in the on-line course. In order to make them easily accessible, they were organized into eleven sections of between twenty to fifty pages each, by grouping of relevant topics together. Quizzes were added to the end of each section to help users review the section's material.

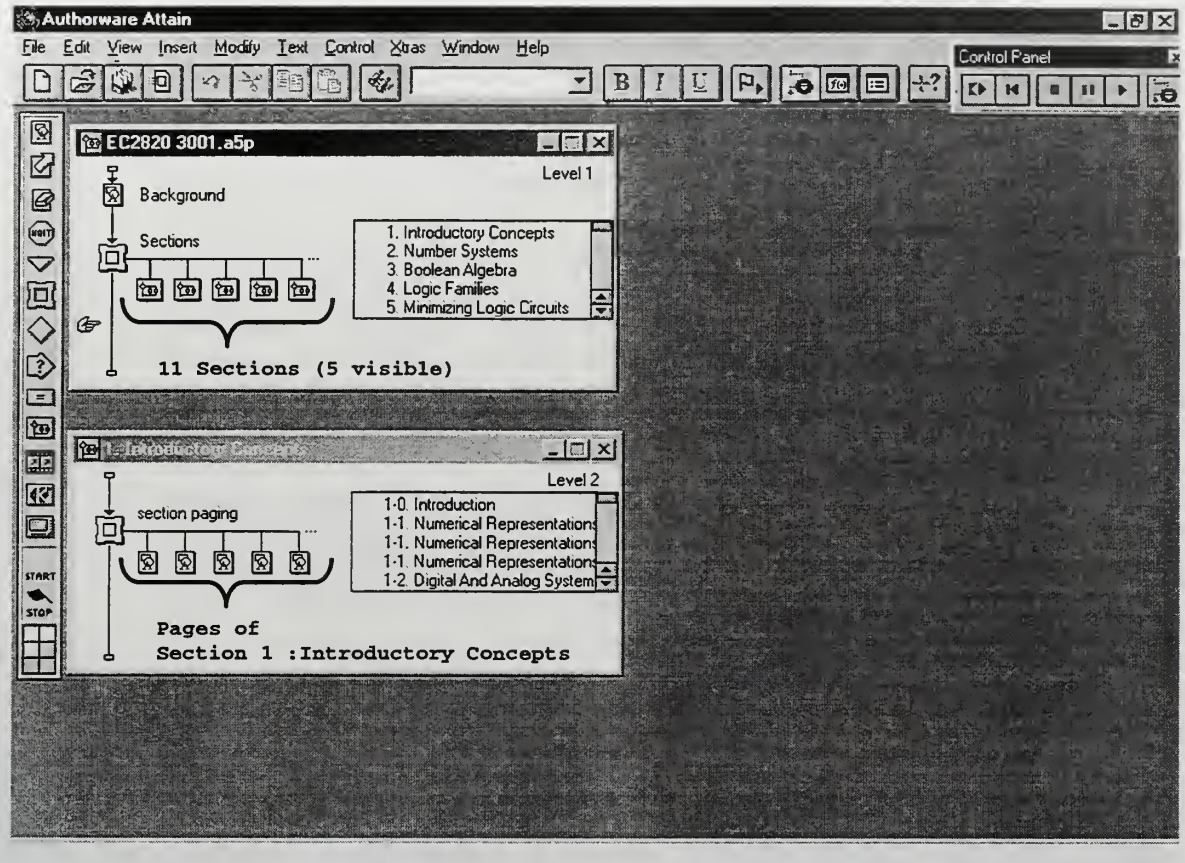

Figure 10. Organization Of Sections And Pages Of The On-Line Course In Authorware

The screen layout used for the EC2820 On-Line Course as seen by the user is shown in Figure 11.

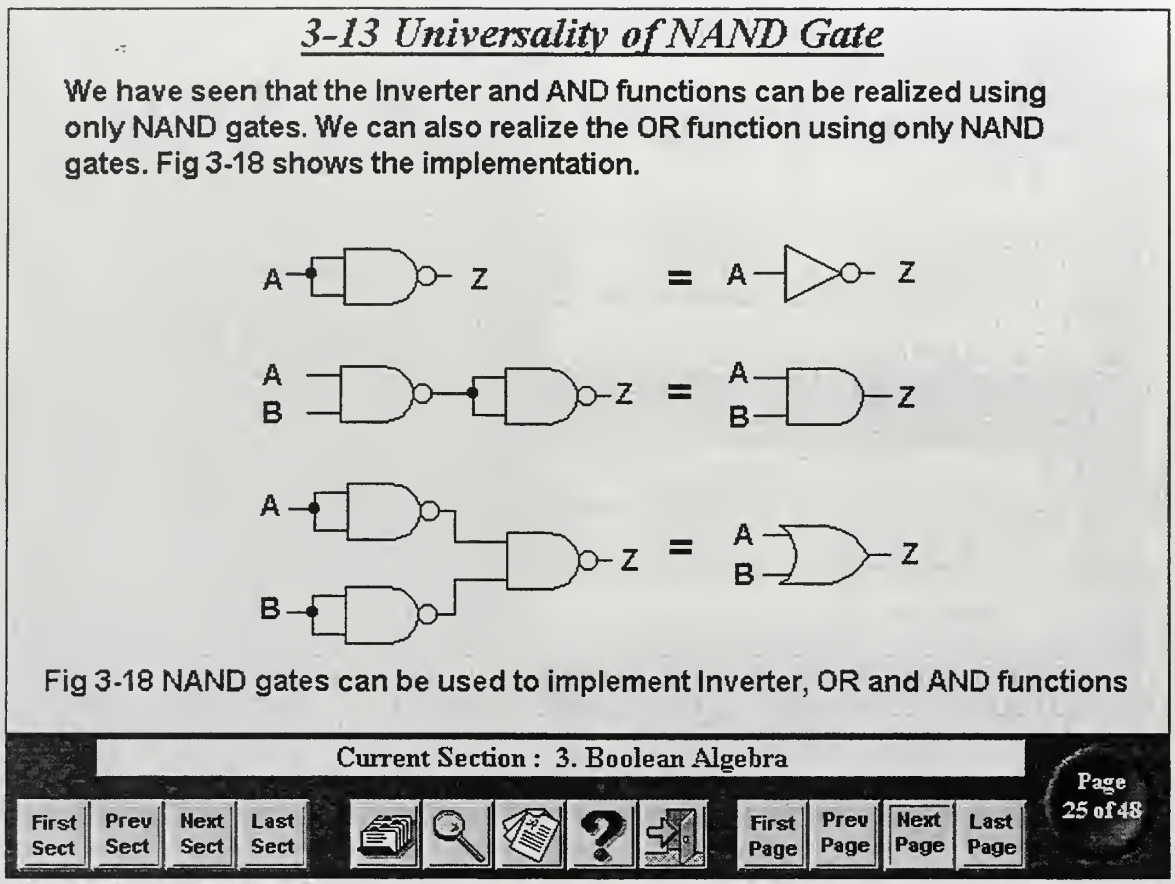

Figure 11. Final Layout Design Used For The EC2820 On-Line Course

Similar to the design of the homepage, a set of guidelines were defined and used in the design of the layout as described below:

- **Look-and-Feel.** To achieve a "clean" look, much space was placed between blocks of information. To achieve this, several layouts, fonts style, color combinations and background picture were tried.

- **Ease of navigation.** The navigation buttons were made user-friendly and were always located in the same position at the bottom of each page. All buttons were made to respond by changing their look or color when they were clicked or moved over.

- **Access to all other pages.** Using the navigation buttons, a user was given the flexibility to move to the first page, last page, from page to page, first section, last section, section to section, search for keyword(s), search for a page, and go back to recently visited pages. The user could also choose to navigate using a pull-down menu.

- **Maximum screen size.** At the point when the on-line course was designed, the biggest display that could fit all computer screens is the 640 pixels by 480 pixels resolution (known as VGA mode).

- **High level of interactivity.** The interactions introduced in the on-line course took the form of user-controlled animations, simple true-false questions, multiple choices questions, fill in the blank exercises, numeric data entry for mathematical problems, and Drag-drop exercises.

A user-controlled animation is shown in Figure 12. Animations were used to demonstrate the step-by-step method of deriving the reflected Gray code from the given binary code. The user is allowed to view the animations at his/her own pace, and repeat the entire process any number of times.

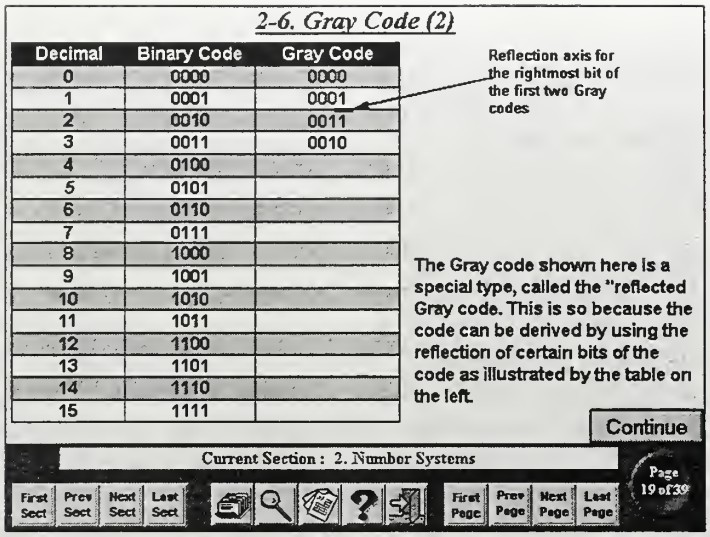

Figure 12. A User-Controlled Animation

A true-false question, a multiple-choice question, and a fill-in-the-blank question are shown in Figure 13, Figure 14 and Figure 15 respectively. The user could participate by selecting an answer for the true-false and multiple-choice question or key in an answer in the case of the fill-in-the-blank question, and then check the correct answer by clicking the "Check Answer" button. If uncertain, he/she could click the "Check Answer" button directly.

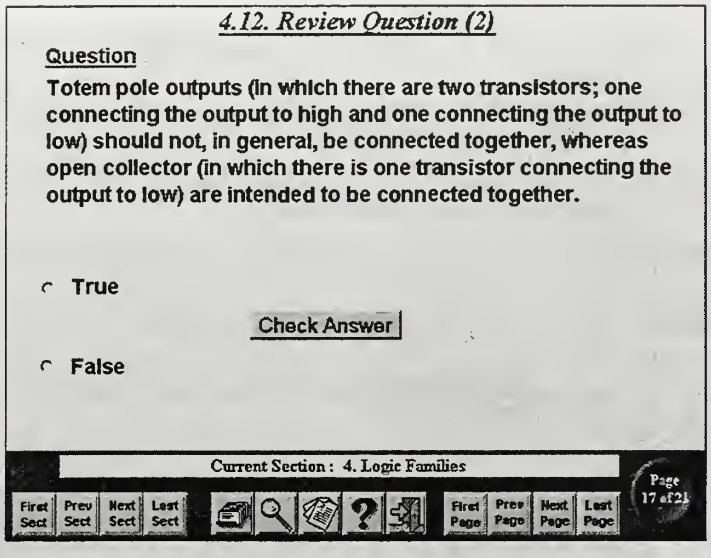

Figure 13. A True-False Question

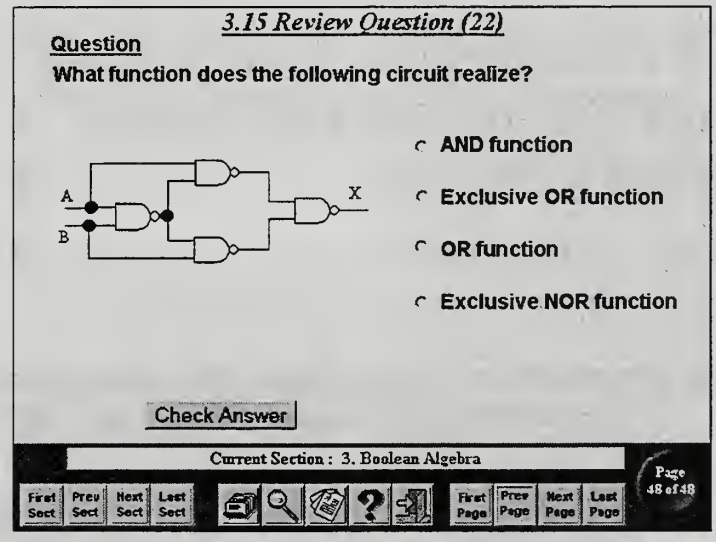

Figure 14. A Multiple-Choice Question

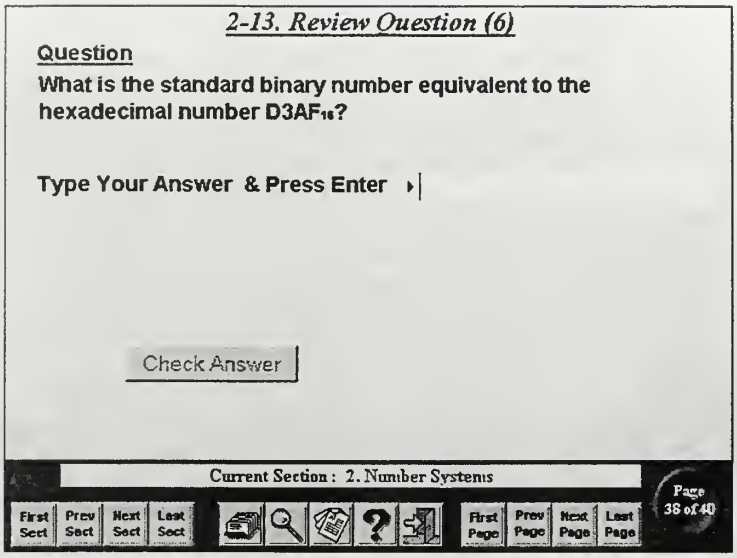

Figure 15. A Fill-In-The-Blank Question

A drag-and-drop question is shown in Figure 16. The user could participate by dragging possible answers, and dropping them into the appropriate blanks, in this case, and then check the correct answer by clicking the "Check Answer" button. Also, he/she could check the answer directly.

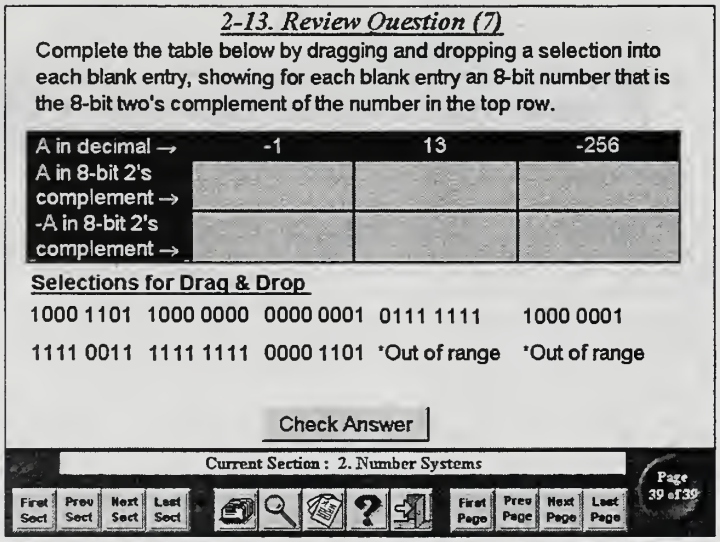

Figure 16. A Drag-And-Drop Question

D. DEVELOPMENT AND TESTING

The development and testing phase was the most task-intensive of all the phases. First, the EC2820 Homepage was constructed, uploaded to the Web server, and tested. Once the homepage was successfully completed, the EC2820 On-Line Course was developed to run from the homepage.

1. Development And Testing Of The EC2820 Homepage

The development of the EC2820 Homepage was done without much difficulty using the Microsoft FrontPage 2000. Frontpage's complete suite of built-in functions such as text editor, graphics editor, website manager, navigation tools, ftp application etc. allowed very rapid development and testing.

2. Development And Testing Of The EC2820 On-Line Course

As for the development of the EC2820 On-Line course, due to its huge size, a popular approach used to design and develop huge software projects known as the incremental development approach was used.

Using the approach, the on-line course project was developed on small incremental steps. It was started with a bare-bone piece and gradually built up by adding more and more content. At each step, additional material was

designed, added and tested before moving on to the next step.

Using this approach, the storyboard of each section, which consisted of between twenty to fifty pages, was first drafted. It was then translated into a digital format, which was made up of text, graphics and animations, suitable for presentation in Authorware. This step was performed with the help of Microsoft Powerpoint and Paint Shop Pro for graphics creation and editing, and Microsoft Word for text editing. Animations and interactions were performed within Authorware.

As more pages were built, 2 types of tests were conducted. The first was called a page test and was conducted very frequently. This was conducted within the Authorware development environment each time a group of two to five pages was completed in Authorware. The page test was carried out to check for layout, bugs, alignment problem, animation synchronization problem, overlapping of text/graphics, page-to-page navigation and other errors specific to the pages. Remedy actions, if required, were taken and the tests were repeated.

The second was called a section test. This test was conducted upon the completion of a section. It required the entire project to be first compiled into a format suitable for publishing on the Web. The test was then carried on the

Web-published version of the project to check for problems/errors with uploading/downloading of the project to and from the web server, compatibility problems with the web browser, navigation when browsing from section to section, page to page using the navigation buttons as well as the menu, keyword(s) and page search, list of recently pages and so forth. Concurrently, the page test was also performed. Again, remedy actions were taken when required and the test was repeated. The steps used in incremental development approach are summarized in Figure 17 below.

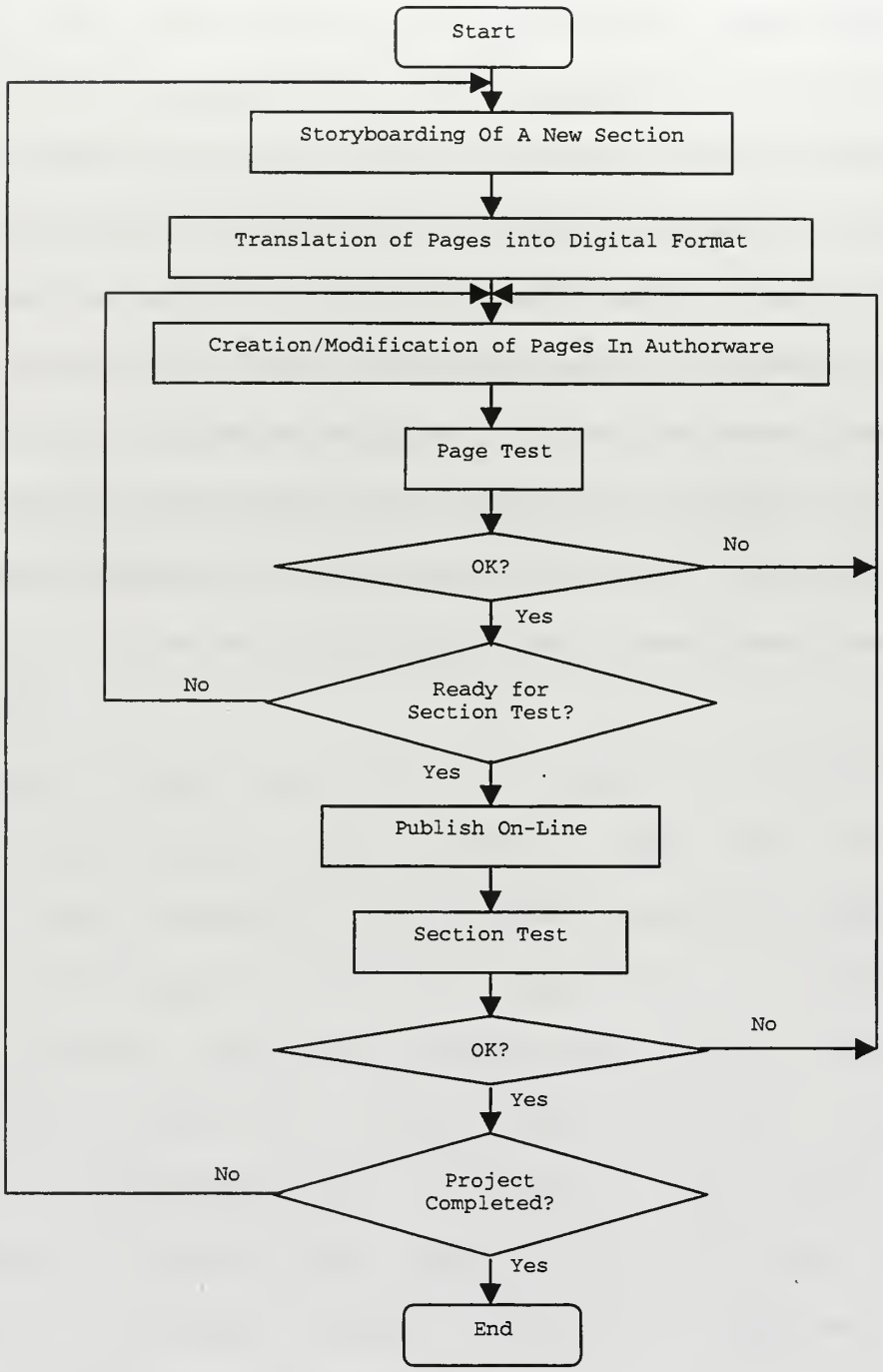

Figure 17. Steps in the incremental development approach

Although the incremental development approach was very tedious, it allowed the author to focus attention on a small

group of tasks at a time at each step, and this reduced the chance of introducing errors into the project, and also helped to detect errors early and confine the extent of error propagation.

Table 5 below gives a breakdown of timings that the author took for coding each type of multimedia component.

S/N	Description	Time Taken
1.	Drawing of a graphic	15 min to 3 hours
2.	Drawing of a table	10 min to 1 hour
3.	Typing of text per page	10 min to 30 min
4.	Coding of an animation	1 hour to 3 hours

Table 5. Breakdown Of Timings For Coding

The graphics drawn could be categorized into 3 types; simple, detailed and complex as shown in figure 18 to 20. On the average a simple graphic would take 15 minutes to 1 hour to produce, a detailed graphic 1 to 1.5 hours, and a complex graphic 2 to 3 hours.

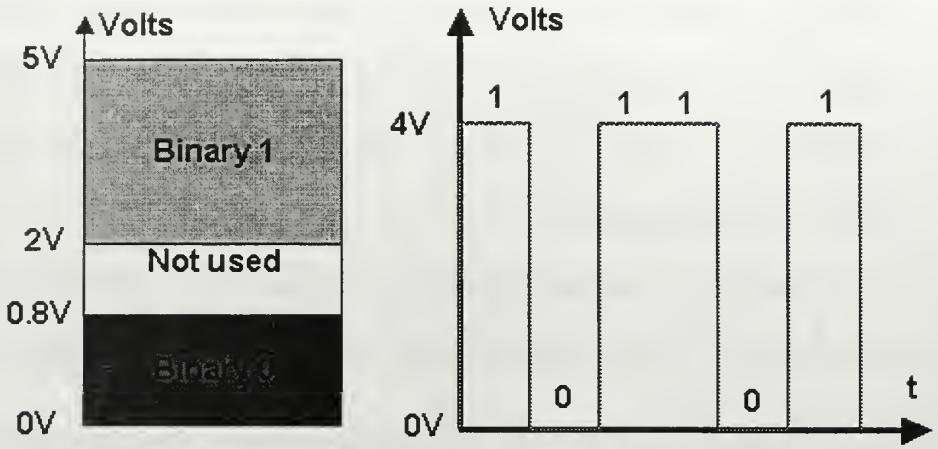

Figure 18. Simple Graphic - 15 Min To 1 Hour To Produce

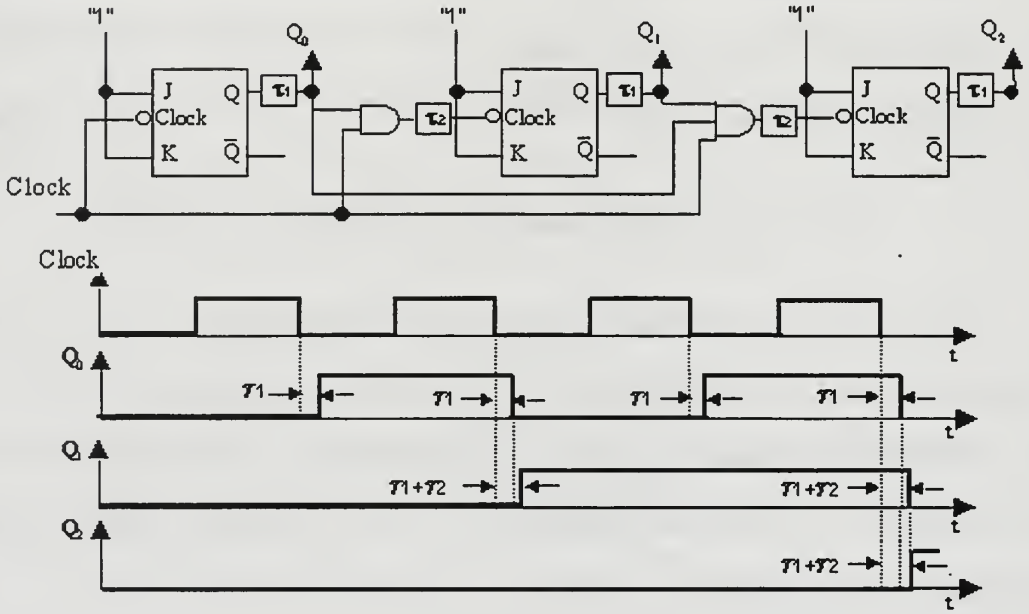

Figure 19. A Detailed Graphic - 1 To 1.5 Hours To Produce

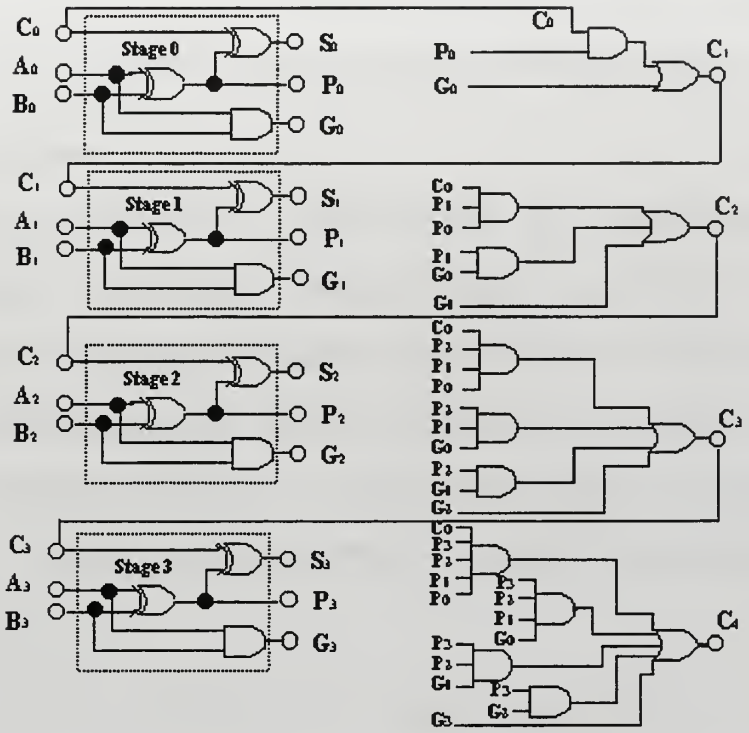

Figure 20. A Complex Graphic - 2 To 3 Hours To Produce

A total of about two hundred graphics was created for the on-line course; 25 percent were simple graphics, 60 percent were detailed ones, and the remaining 15 percent were complex ones. It is apparent that much time and effort has to be invested in the creation of graphics for on-line course development. Having a graphic artist as part of the development team would certainly help speed up the development work tremendously.

E. IMPLEMENTATION

In the implementation phase, the EC2820 Homepage and the EC2820 On-Line Course were successfully completed and

tested, and were officially published in March 2000 on the ECE Department's Web server that was catered for distributed learning.

Evaluation was conducted to gather feedback and suggestions while this prototype on-line course was in use.

Besides using the completed Authorware project for the on-line course, it could be used as an effective tool for classroom teaching, and also it could be burned into a CD-ROM for distribution to students on a distributed learning program.

V. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

This thesis project has been an extended learning process about the World Wide Web and its associated technologies. The author has gained a substantial amount of knowledge and technical skills from completing this thesis project in many areas of Web technology including Web publishing, Web animations, Web based learning, and Web administration.

The EC2820 Homepage and On-Line Course, that were created, offered many facilities to the user which provided a flexible and interesting learning environment. Anyone in the world with a computer and an internet connection could access the information, thus increasing the target audience.

The homepage which, when compared to many other sites, was very well presented and easy to use. The on-line course allowed significant user interaction, and thus was an effective learning tool. However, both products were by no means finished and like all Web pages, they needed to be continually updated to provide the user with better information and features. There were two features, sound and video, that the author felt could have been added to make the on-line course more effective and complete.

This thesis project has sought the following answers to the research questions posted in Chapter I.

1. Which Recent Web Technology Is The Most Suitable, And Also Cost/Time-Effective For The Production Of WBT ECE Courses?

Several recent technologies were investigated and their pros and cons were examined. These technologies included:

- Publishing lecture materials directly on web pages.
- Publishing lecture materials in the form of slide shows that run on the web browser.
- Developing WBT course using a high level language such as Java, Visual Basic etc..
- Developing WBT course using a proprietary software package.
- Developing WBT course using commercial-off-the-shelf (COTS) authoring tools such as the Macromedia Authorware 5.

In consideration of its moderately short development time, good maintainability and upgradeability, excellent ability to add interactivity and animation to the WBT course, and also its cost effectiveness, the use of COTS authoring tools was found to be the most suitable technology for future development of ECE WBT courses. In particular, the use of the Microsoft Frontpage 2000 and the Macromedia Authorware 5 were highly recommended for use in creating course homepages and WBT courses respectively due to their

short learning curve and the many powerful features that came with the software.

2. What Is The Recommended Approach, Design And Development Process That Should Be Adopted For Future Productions?

The incremental development approach was used for the thesis project development. It was popular for developing huge software projects, and in fact, the author had a prior opportunity to use it for his projects in a Java programming class.

The approach called for small incremental steps in the development. The project was started with a minimal functionality and gradually built up step-by-step. At each step, additional content was designed, added and tested before moving on to the next step.

It is without doubt that this methodical approach had led to the successful completion of the thesis project. The breakdown of the development work into steps and detailed tasks required at each step had been discussed in Chapter V.

3. What Are The Trainings Required For Such Production?

To successfully produce a effective WBT course, the following knowledge, skills and resources must be made available:

- **Knowledge of course content.** Usually the instructor has to get involved in advising what materials to include in the WBT course. It would be of great help to the quality of the development if the developer also has a good knowledge of the course content.

- **Multimedia software.** Multimedia software can be used to produce WBT courses that are effective learning tools. It is imperative that the developer receives formal training on the required software to attain a high level of proficiency so that he can bring out the best in these software in the shortest time possible.

- **Teaching skills and WBT exposure.** It would help a great deal if the developer has some previous traditional teaching experience as that would equip him with the skills of deciding the manner information is organized and presented for effective learning. As there is a great difference between traditional teaching and WBT, that is, the absence of instructor-student face-to-face interaction in WBT, the developer should be exposed to WBT environment to learn more about its constraints and its strong points such as the animation capability that can be used to illustrate difficult concepts, and the interaction capability that can be used to engage the active involvement of the student. With this knowledge, he can target the content to be presented in different ways, meeting the needs of different learning styles

- **Graphic design.** It is inevitable that the developer have graphics design and editing skills. They are required to transform figures, tables, and photos in its raw form into compressed computer format or to produce any animation required.

B. RECOMMENDATIONS

1. Formalize Training

Developers must be well trained in the required multimedia software tools in order to produce effective WBT

courses using the least time and cost. The training approach used by the author, in which he self-learned all the required software tools, was time-consuming and tedious. The time taken could be easily halved using formal training methods, hence allowing more time to be channeled into more productive development work.

There are two recommended methods of providing formal training to the developers. One method is to send them for short commercial courses that are application specific. The other method is to incorporate the required training into some of the relevant courses currently conducted in NPS. Potentially, there are three Computer Science (CS) courses that could introduce multimedia software training namely CS3202 - Introduction To Multimedia Production (learning Macromedia Director is part of the course syllabus), CS3203 - Advanced Multimedia Production (good candidate for Macromedia Authorware training) and CS3505 - The Internet And The Information Highway (good candidate for Frontpage 2000 or Macromedia Dreamweaver training).

The commercial course method is more suitable if the number of developers to be trained is small, and also if the training required is immediate or when the schedule of the internal NPS courses could not fit in the project schedule.

Since many NPS departments are interested in distributed learning and some departments have already initiated various projects in that area, there will be many

faculty members and developers who will require training in multimedia software tools. This being the case, the incorporation of the training into some of the NPS courses is a more cost-effective option.

2. Introduce Instructional Management Systems (IMS)

With Instructional Management Systems (IMS), the administrator of the WBT course can efficiently plan, produce, administer, and deliver curricula, as well as track, store, and report student progress from anywhere in the world, for any number of students at multiple locations.

Using IMS, students have to login using ID and password, which enables the IMS to automatically track their individual actions. An IMS database will hold names, locations, and other student and course information. The IMS can manage course administration and planning, student registration and enrollment, and the assignment of specific training courses to subsets of the student population. It also provides automatic tracking and statistics of student progress and test scores. Limited IMS is supported by the current version of Macromedia Authorware. For more complete IMS functions, the Macromedia Pathware 4, which is fully compatible with Authorware, is recommended.

3. Standards: Provide A Platform For Interoperability

In line with the recommended introduction of IMS, standards for developers to provide the requisite level of interoperability have to be established when efforts in the area of distributed learning are still evolving, with work coming from different interest groups.

Standards improve the return on investment by providing a framework for interoperability. Interoperability holds the key to the reuse and integration needed for tomorrow's sophisticated distributed learning. Also, by providing a set of standards identifying specific trackable information, developers can build WBT courses which can link to a common management system. This will allow the school to better manage and track instruction.

The benefits of having a standards-based integrated teaching and learning system are vast, including:

- Providing immediate feedback so that students and instructors can take action as needed.
- Providing a comprehensive library of training materials in one repository.
- Sharing of content and resources.
- Providing reports to allow for better measurements of usage and results.
- Minimizing costs associated with the implementation of multiple systems.
- Support for a wide selection of authoring tools.

4. Explore Video And Real-Time Interaction

The use of video and real-time interaction is being facilitated by higher bandwidth, decreasing cost and availability of new Web technologies.

Lectures can be recorded, digitized and broadcasted live over the Web at specific times, and students using a computer and a internet connection, can attend the lecture at the comfort of their home and interact real-time with the lecturer.

Alternatively, lectures can be pre-recorded, digitized, and broadcasted at scheduled times over the Web and students can watch them and send questions via email to the lecturer.

5. Use Author's Project As Template

It was felt that this report would give any future student who would be interested in developing similar project a good understanding of what is achievable and how to achieve it.

The incremental development approach used by the author has been a key factor in the successful completion of the project and is strongly recommended for future development.

The reuse of some of the Authorware codes for the EC2820 On-Line Course such as the code for the section-to-section and page-to-page navigation, true-false, multiple

choice questions, drag-drop exercises, animations etc., would certainly help reduce the overall development time.

It is hoped that the homepage and on-line course provide people with many hours of enjoyment and that it will be further improved by future students as emerging technologies permit.

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APPENDIX A. USING MULTIMEDIA FOR DISTRIBUTED LEARNING

A. WHAT IS MULTIMEDIA?

A commonly used definition of "multimedia" is:

> Digital multimedia is the field concerned with the computer-controlled integration of text, graphics, still and moving images, animation, sounds, and any other medium where every type of information can be represented, stored, transmitted, and processed digitally. [Ref. 1]

B. WHY MULTIMEDIA?

Over the past few years, multimedia has proven itself to be one of the most effective tools in education. Multimedia uses a combination of the text, graphics, animation, sounds, video etc. to create a dynamic, visual presentation that catches the users' attention and maintains their interest throughout the presentation significantly reducing the time needed to comprehend material.

In essence, multimedia can play a key role in improving the delivery of instructional content by: [Ref.10]

- Presenting media in visual, graphical way using animation, video and other forms of multimedia.
- Using audio to expand sensory input.
- Creating "learning by doing" exercises.
- Offering learners the ability to control the pace and flow in a non-threatening, patient manner.

- Providing a framework for collaboration for students and instructors.
- Managing the learning environment.
- Offering instruction any place, any time.

C. METHOD OF INSTRUCTION VS MULTIMEDIA

The success of a WBT course as a good learning environment depends on the method of instruction as in the traditional training situation. Only through proper teaching methods can we captivate, motivate, and excite our users to be actively involved in the learning process. The choice of multimedia is secondary.[Ref. 2]

Therefore, it is of paramount importance that the instructor, that teaches the course in traditional method, authors the WBT course or plays a major role in designing the WBT course.

In order to be as effective as in a traditional training situation, the WBT course should make good use of multimedia to focus on demonstrating, animating and explaining a topic, giving the users ample opportunity to practice, and paying particular attention to feedback and response.

D. IMPORTANCE OF INTERACTIVITY

Interactivity is one of the main attractions of using multimedia. It helps increase the users active participation in processing the course material. In general, a more active user will understand and retain knowledge more readily than a passive user.

The strategies to ensure that users participate actively include requiring them to answer different types of question (true & false, multiple choice, fill in the blanks, and mix & match), step through animations, navigate through screens, and decide the topic to learn.

A study by J.D Fletcher for the Institute for Defense Analysis found that interactive applications improve achievement by up to 25 percent over conventional training. Similar studies at university level have shown proficiency increments of up to 40 percent while cutting instruction time by half. [Ref. 2]

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